Designing and Managing Livestock Waste Lagoons in Illinois

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Introduction

Growing environmental concerns and stringent laws controlling disposal of animal waste and surface run-off make it more important than ever that today's farmers select the most appropriate waste-handling system. The type of system used will depend on economics, regulation, and the farmer's situation. Local factors such as cost, size and number of animals, soil type, and topography, and external factors such as regulations, climate, and proximity to housing must all be considered.

Pit systems store manure until it is returned to the land. However, where land is scarce and leaching levels are high, these systems may present a pollution problem. Composting and the use of additives for decomposition are only convenient in small-scale intensive systems. Livestock waste lagoons, however, not only handle manure in the liquid form for convenience and low labor, they treat and stabilize livestock manure while meeting the requirements of state and federal law.

Waste lagoon systems treat and store livestock manure for disposal onto land. They also store waste water for irrigation and flushing. Systems can be compatible with irrigation equipment, and they have reasonable construction costs and minimal fly problems. Livestock waste lagoons do require periodic sludge removal and careful management to prevent the pollution of groundwater and the emission of powerful odors.

To avoid problems with odor and sludge, lagoons must be large enough for sludge to decompose biologically. Lagoons must also be loaded gradually and consistently at the start, taking care to avoid overloading.

Once in full operation, a lagoon must never be pumped below the minimum design volume. The minimum design volume is the volume the lagoon requires to ensure efficient bacterial action for continuous decomposition of livestock waste manure. Waste treatment efficiency can be improved by weekly agitation, though this can increase odor problems. This agitation can be performed by a tractor-powered lagoon pump. The sides of the lagoon should also be maintained by planting grass and mowing regularly.

Types of Lagoons

Aerobic, anaerobic, and facultative lagoons

A livestock lagoon treats manure as a liquid, the manure having been diluted by wash water and runoff. The lagoon acts as a biological tank, decomposing the waste before it is utilized as a resource in the form of irrigation liquid. The biological reaction is achieved by either anaerobic bacteria (these bacteria are inhibited by oxygen), aerobic bacteria (these bacteria require oxygen), or facultative bacteria (these bacteria decompose the waste, with or without oxygen).

To operate successfully, aerobic lagoons require shallow depths and large surface areas because the aerobic process requires huge amounts of oxygen and sunlight. This system is impractical for many farms because large areas of flat land have to be sacrificed to accommodate it. Aerobic lagoons do control sludge and odors better than anaerobic ponds, but they may need mechanical aerators to do so.

Anaerobic lagoons are most commonly used for livestock waste treatment. They can store, dilute, and treat high loading rates of livestock waste rather inexpensively with minimal labor and maintenance. The land area needed to construct such a lagoon is also relatively small, making the anaerobic lagoon practical for many operations.

Facultative lagoons combine the benefits of anaerobic and aerobic decomposition. In the anaerobic process, some offensive gases may be emitted, leading to odor problems. An aerator can be used to make the top of the lagoon aerobic, reducing odors.

Anaerobic single-stage versus anaerobic multiple-stage lagoons

Anaerobic livestock waste lagoons are divided into two categories: single-stage lagoons and multiple-stage lagoons (Figures 1 and 2). In multiple-stage lagoons, the effluent produced in the first stage or cell is transferred to the secondary cells where further treatment occurs through bacterial action and oxidation. In single-stage lagoons, there is no secondary treatment. The advantage of the secondary treatment is that it reduces undesirable odors, and it reduces the possibility that disease may be transmitted when the lagoon water is used for flushing gutters.

The design volume required to construct a multiple-stage lagoon is approximately twice that of a single-stage lagoon. Construction costs can be cut by siting the two lagoons side by side so that they share a common wall. Operators often overlook the option of building a secondary cell, but the advantages may far exceed the costs, especially in areas that are close to residential buildings.

Operators of single-stage lagoons who wish to benefit from the advantages of multiple-stage lagoons may add a second stage at least 50 percent of the size of the first lagoon. If the water in the second stage is going to be used for flushing, this size may be increased to 75 percent. This will leave the first stage at the minimum design volume and allow water to be taken only out of the second stage (Figure 2).

Figure 1. Single-cell anaerobic lagoon

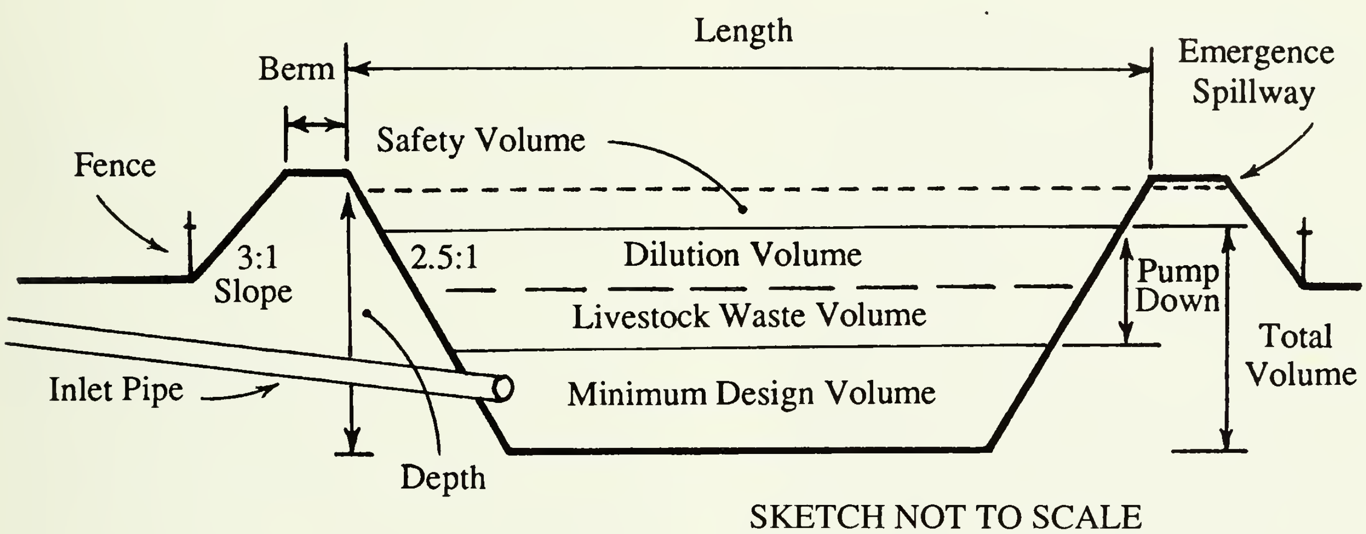
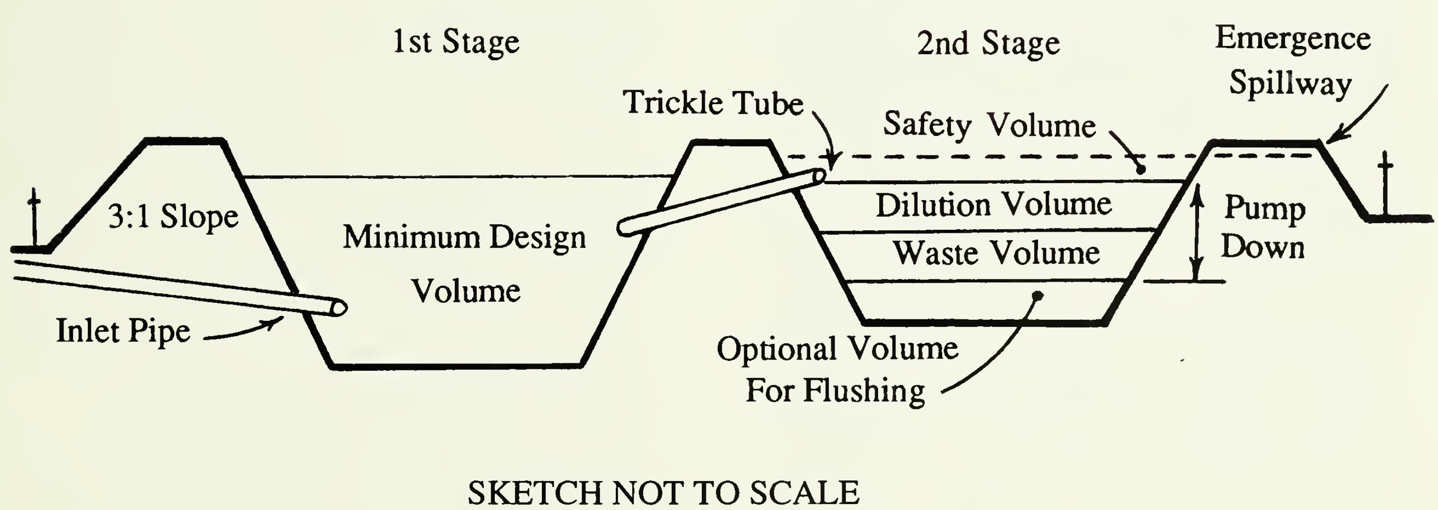


Figure 2. Two-cell multiple-stage anaerobic lagoon



Design Constraints for Proper Operation

Federal, state, and local regulations

Illinois law does not require a permit for a no-discharge system such as a livestock waste lagoon. Federal law does regulate agricultural pollution; certain laws prevent wastes from entering public waters and others prevent the emission of strong odors. Essentially, the law states that no effluent may be discharged unless the discharge is a result of a specified storm; and to accomplish this, the technology used must comply with the no-discharge limitations where it is economically and technically possible. If the system is built to discharge, a National Pollutant Discharge Elimination System (NPDES) permit is required.

Current Illinois laws require that lagoons must be protected against excessive water from floods and storms. The standard used is a one-in-ten-year flood and a 25-year, 24-hour storm. Lagoons must have a "freeboard" or excess capacity adequate for such a storm. The law also prohibits building a lagoon within a ten-year flood plain. A lagoon cannot be sited within one-half mile of a populated area or within one-fourth mile of a nonfarm residence, although there are exceptions to this law. Lagoons must also be built on soil of low permeability, or they must be sealed against contamination of groundwater.

Loading and sludge accumulation rates

To load a lagoon, fill it with water from one-third to one-half of its total volume. Then add manure consistently and in increasing amounts until the total volume level is reached. While loading the lagoon, never allow the volume to drop below the minimum design volume. Use a highly visible post gauge marked at minimum design volume and safety volume levels so that these stages can easily be recognized (Figure 1).

It is best to start a lagoon in the spring because warmer weather increases bacterial action; this activity helps to ensure correct operation of the lagoon and minimizes odors. Regular loading of the lagoon—daily or weekly—also protects against undesirable odors. In winter, when temperatures are low and waste decomposes more slowly, it is best to store or land-apply as much manure as possible to reduce the load on the lagoon.

Lagoon loading rates depend on the size, number, and species of animal kept and the latitude of the location. For example, a swine farm located in southern Illinois can load a lagoon with more waste than a farm in northern Illinois with a lagoon that is the same size. Because of this difference, Tables 1, 2, and 3 are provided to help determine the correct volume for central, northern, and southern Illinois.

The sludge accumulation rate of a lagoon varies with loading rates and is difficult to predict. Cattle lagoons accumulate sludge more rapidly than swine lagoons. If the manure contains bedding (bedding has a slow decomposition rate), the sludge accumulation rate will be higher.

Measure the sludge accumulation rate at least once a year to assess the lagoon's efficiency. If sludge accumulates rapidly, pump it out and apply it to the land, either by incorporating or injecting it into the soil. Then refill the lagoon with fresh water to its minimum design volume.

Frequency of dewatering

The volume of water in a lagoon increases constantly due to surface runoff, water added from the livestock operation, and direct precipitation. When the lagoon's water line approaches the safety level, pump the lagoon down (dewater it). Some lagoons may need to be dewatered every six months to return them to the minimum design volume. Dewatering controls mineral buildup, prevents overflow, and reduces the amount of sludge. It also provides nutrients to crops.

Various types of irrigation equipment can be used for dewatering. This process can cause odor problems, so try to dewater when the wind is blowing away from neighbors.

Other factors that influence how often dewatering should occur are salt concentration and soil type. To a certain extent, the soil type of the area where the water is to be pumped affects dewatering. It may not be possible to dewater every six months if the land area is small or if the area is already high in certain salts or nutrients. Soil tests are advisable.

Water supply and drainage

When starting up a lagoon, allow clean surface water such as roof drainage and rainwater to fill the lagoon to the desired level. After the lagoon is filled to about one-third capacity, there may be a need to divert runoff water to reduce the filling rate.

In an anaerobic lagoon, use enough water to maintain the minimum design volume depth. If less water is entering the lagoon because of low rainfall, the lagoon may need to be diluted with clean water to reduce salt concentrations. It is very important that the lagoon does not overflow, so gutter any extra water from roofs of buildings to channel it away from the lagoon. All water added to a lagoon before dewatering is the dilution volume, and for a specific length of time, this volume should be approximately equal to the livestock waste volume (Figure 1). Where surface runoff is inadequate, find a viable source of dilution water, such as water from ponds and wells.

Species and expected values of manure production

The design of a livestock waste lagoon is influenced by the quantity and composition of the manure entering it, which depends on animal species, age, stage of production, and the environment.

Published manure production values include not only feces and urine but also average amounts of waste water and other materials that find their way into the waste collection system. For example, a livestock waste facility for a swine nursery unit may have to handle three to four times as much waste as the actual feces and urine produced due to the large amounts of wash and waste water entering the system.

Soil and location

Lagoons should be positioned over nearly impermeable soil that can seal the bottom and side walls. Soil Conservation Service and Cooperative Extension Service personnel can help determine a soil's suitability for lagoon siting. Remove and seal field tile lines that cross the site to prevent the lagoon from becoming a pollution hazard. Avoid sandy sites and sites close to limestone unless the lagoon is lined with clay or soil cement. Liners can be used, but they are initially expensive and difficult to install. Over time, the lagoon seals naturally due to the buildup of animal waste in the form of sludge.

When siting a lagoon, remember these important criteria. A lagoon cannot be within 200 feet of a water well unless the well is owned by the lagoon's owner. In this case, the lagoon can be as close as 75 feet to the well, but this situation is not recommended. For convenience, a lagoon should be downhill from the source of manure, and it should be far enough away from streams to prevent pollution.

Finding the Recommended Volume

A livestock waste lagoon should be large enough for efficient bacterial decomposition of a certain amount of diluted manure over a specific period of time. The total volume required equals the sum of the lagoon's minimum design volume, waste storage volume, and dilution volume. Figures 1 and 2 illustrate these four volume components for properly designed single- and multiple-stage anaerobic lagoons.

Minimum design volume

The minimum design volume is the volume the lagoon requires to ensure efficient bacterial action for continuous decomposition of livestock waste manure. The liquid level of waste in the lagoon should never drop below the minimum design volume. If this happens, decomposition will be poor and odor problems will occur.

Livestock waste volume

The livestock waste storage volume equals the total amount of waste produced by the livestock operation for a specific period of time. This volume will depend on whether the lagoon is dewatered once or twice a year. If a lagoon is dewatered once a year, the livestock waste volume will be double that of a lagoon dewatered twice a year. If coarse solids are removed from the liquid manure before it enters the lagoon, the total lagoon design volume can be reduced by up to 25 percent. Either a settling tank or a mechanical separator can remove solids from the liquid manure stream; solids are then available for land application or perhaps composting.

Dilution volume

The dilution volume for any type of livestock waste lagoon in Illinois should be approximately equal to the livestock waste volume. The dilution volume includes all extra water such as building wash water, spillage from livestock watering devices, feedlot runoff, direct precipitation, and water pumped from a well or stream.

Determining the volume

Tables 1, 2, and 3 recommend total and minimum design volume for both single- and multiple-stage, one- or two-dewatering lagoons. Use the appropriate table for your particular location, and consult the left-hand column of that table for the type and weight of animal kept. Across from this column, find the minimum design volume and total volume values for single- or multiple-stage lagoons that are dewatered once or twice a year.

Now find the total volume line, labeled "total," and look for the column that applies to your particular situation. There are two main choices: one or two dewaterings per year and single- or multiple-stage lagoons. The figures give total volume for single-stage lagoons and total volumes for each lagoon in a two-stage system. The number represents the volume of the lagoon in cubic feet; this figure must be multiplied by the number of animals at that given size. For different animals and different weights, all the volumes must be found and added together to give the grand total volume. The minimum design volume is also given as a guide for initial filling of the lagoon and for its pumping down. This figure is found in the row above the total volume labeled "mdv." The total volume does not include the safety volume; this is taken into account in the dimensions given in Table 4.

Table 1. Determining Volume for Lagoons in Central Illinois

	Weight, lb.		One dewatering			Two dewaterings		
			Single-stage	Multiple-stage 1st	Multiple-stage 2nd	Single-stage	Multiple-stage 1st	Multiple-stage 2nd
Swine:			cubic feet of lagoon volume per animal					
Nursery pig	35	mdv	48	44	13	48	44	12
		total	75	44	40	62	44	27
Growing pig	65	mdv	88	82	23	88	82	23
		total	140	82	75	114	82	49
Finishing hog	150	mdv	203	188	53	203	188	53
		total	323	188	173	262	188	113
Gestation sow	275	mdv	372	344	97	371	344	96
		total	592	344	317	482	344	207
Sow + litter	375	mdv	507	469	132	506	469	131
		total	807	469	432	657	469	282
Beef:								
	500	mdv	750	625	251	750	625	252
		total	1,090	625	590	920	625	420
	750	mdv	1,125	938	376	1,125	938	378
		total	1,635	938	895	1,380	938	630
	1,000	mdv	1,500	1,250	500	1,500	1,250	504
		total	2,180	1,250	1,180	1,840	1,250	840
	1,250	mdv	1,875	1,562	626	1,875	1,562	630
		total	2,725	1,562	1,475	2,300	1,562	1,050
Dairy:								
	150	mdv	264	225	75	263	225	75
		total	412	225	225	338	225	150
	250	mdv	440	375	125	438	375	125
		total	688	375	375	563	375	250
	500	mdv	880	750	250	878	750	250
		total	1,375	750	750	1,125	750	500
	1,000	mdv	1,760	1,500	334	1,755	1,500	500
		total	2,750	1,500	1,000	2,250	1,500	1,000
	1,400	mdv	2,464	2,100	700	2,457	2,100	700
		total	3,850	2,100	2,100	3,150	2,100	1,400

NOTE: mdv = minimum design volume; total = total volume.
SOURCE: Values in this table are derived from *Design and Operation of Livestock Waste Lagoons* by D.D. Jones and A.L. Sutton, 1977.

Table 2. Determining Volume for Lagoons in Northern Illinois

	Weight, lb.		One dewatering Single-stage	One dewatering Multiple-stage 1st	One dewatering Multiple-stage 2nd	Two dewaterings Single-stage	Two dewaterings Multiple-stage 1st	Two dewaterings Multiple-stage 2nd
Swine:			cubic feet of lagoon volume per animal					
Nursery pig	35	mdv	54	50	15	54	50	14
		total	85	50	45	70	50	31
Growing pig	65	mdv	100	93	26	100	93	26
		total	159	93	85	129	93	56
Finishing hog	150	mdv	230	213	60	230	213	60
		total	366	213	196	297	213	128
Gestation sow	275	mdv	422	390	110	421	390	109
		total	671	390	359	547	390	235
Sow + litter	375	mdv	575	532	150	574	532	149
		total	915	532	490	745	532	320
Beef:								
	500	mdv	851	709	285	851	709	286
		total	1,236	709	669	1,043	709	476
	750	mdv	1,276	1,064	426	1,276	1,064	429
		total	1,854	1,064	1,015	1,565	1,064	714
	1,000	mdv	1,701	1,418	567	1,701	1,418	572
		total	2,472	1,418	1,338	2,087	1,418	953
	1,250	mdv	2,126	1,771	710	2,126	1,771	714
		total	3,090	1,771	1,673	2,608	1,771	1,191
Dairy:								
	150	mdv	299	255	85	298	255	85
		total	467	255	255	383	255	170
	250	mdv	499	425	142	497	425	142
		total	780	425	425	638	425	284
	500	mdv	998	851	284	996	851	284
		total	1,559	851	851	1,276	851	567
	1,000	mdv	1,996	1,701	379	1,990	1,701	567
		total	3,119	1,701	1,134	2,552	1,701	1,134
	1,400	mdv	2,794	2,381	794	2,786	2,381	794
		total	4,366	2,381	2,381	3,572	2,381	1,588

NOTE: mdv = minimum design volume; total = total volume.
SOURCE: Values in this table are derived from *Design and Operation of Livestock Waste Lagoons* by D.D. Jones and A.L. Sutton, 1977.

Table 3. Determining Volume for Lagoons in Southern Illinois

	Weight, lb.		One dewatering Single-stage	One dewatering Multiple-stage 1st	One dewatering Multiple-stage 2nd	Two dewaterings Single-stage	Two dewaterings Multiple-stage 1st	Two dewaterings Multiple-stage 2nd
Swine:			cubic feet of lagoon volume per animal					
Nursery pig	35	mdv	42	38	11	42	38	10
		total	65	38	35	54	38	23
Growing pig	65	mdv	76	71	20	76	71	20
		total	121	71	65	99	71	42
Finishing hog	150	mdv	176	163	46	176	163	46
		total	280	163	150	227	163	98
Gestation sow	275	mdv	322	298	84	321	298	83
		total	513	298	275	417	298	179
Sow + litter	375	mdv	439	406	114	438	406	113
		total	699	406	374	569	406	244
Beef:								
	500	mdv	650	541	217	650	541	218
		total	944	541	511	797	541	364
	750	mdv	974	812	326	974	812	327
		total	1,416	812	775	1,195	812	546
	1,000	mdv	1,299	1,083	433	1,299	1,083	436
		total	1,888	1,083	1,022	1,593	1,083	727
	1,250	mdv	1,624	1,353	542	1,624	1,353	546
		total	2,360	1,353	1,277	1,992	1,353	909
Dairy:								
	150	mdv	229	195	65	228	195	65
		total	357	195	195	293	195	130
	250	mdv	381	325	108	379	325	108
		total	596	325	325	488	325	217
	500	mdv	762	650	217	760	650	217
		total	1,191	650	650	974	650	433
	1,000	mdv	1,524	1,299	289	1,520	1,299	433
		total	2,382	1,299	866	1,949	1,299	866
	1,400	mdv	2,134	1,819	606	2,128	1,819	606
		total	3,334	1,819	1,819	2,728	1,819	1,212

NOTE: mdv = minimum design volume; total = total volume.
SOURCE: Values in this table are derived from *Design and Operation of Livestock Waste Lagoons* by D.D. Jones and A.L. Sutton, 1977.

Finding the Right Dimensions

Depth

Permissible depth varies widely according to site and location. Table 4 gives four different depths for each volume; build the lagoon as deep as possible without getting closer than 4 feet to the highest expected water table level. A deep lagoon provides reduced surface area, better mixing qualities, reduced odor emission, and a smaller shoreline for better mosquito control. The depths given include the 2 feet of freeboard needed for the safety volume.

Length-to-width ratio

After determining the volume of the lagoon and deciding on the appropriate depth, use Table 4 to determine the length-to-width ratio of the inside of the lagoon. For example, if a 350,000-cubic-foot lagoon is to be built 20 feet deep, the dimensions 175 feet by 200 feet can be derived by using Table 4. These dimensions were chosen to give a roughly square lagoon. Single-stage lagoons are usually square or circular, while multiple-stage lagoons may be more rectangular (Figure 3).

The amount of space available will limit the lagoon's shape; it is important to allow for an 8-foot top width for the berm and space for the outside dry slope in addition to the dimensions derived from the table. Plan well ahead and think about possible extension in the future or adding a second stage if constructing a single-stage lagoon.

Side slopes

Table 4 assumes inside slopes of 2.5 to 1. Slopes that are steeper than this may require gravel riprap to stop erosion. If a dash appears in Table 4, the lagoon design is not possible because the slopes collide in the middle.

Figure 3. Barn, feedlot, and multiple-stage lagoon

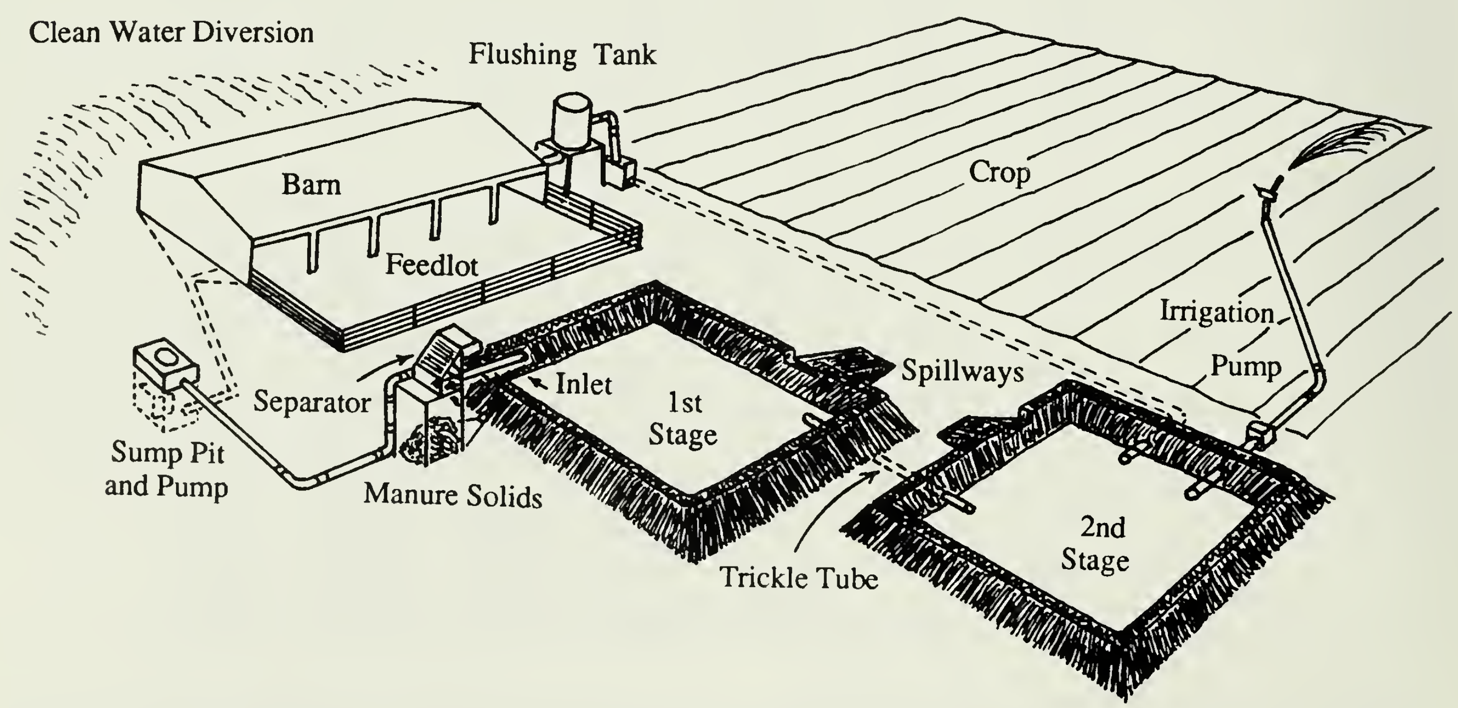


Table 4. Interior Dimensions for Livestock Waste Lagoons

Bank slope = 2.5:1; dimensions include 2-foot freeboard; all dimensions in feet, unless otherwise specified.

	Depth											
	10			12			15			20		
Volume	Interior width			Interior width			Interior width			Interior width		
1,000s cu ft	100	150	200	100	150	200	100	150	200	100	150	200
	Interior length											
10	46	-	-	-	-	-	-	-	-	-	-	-
20	64	50	-	63	-	-	63	-	-	-	-	-
30	82	60	-	78	-	-	77	-	-	-	-	-
40	100	71	-	93	68	-	90	68	-	-	-	-
50	117	81	66	109	77	-	103	75	-	-	-	-
60	135	91	73	124	85	70	117	82	70	103	-	-
70	153	102	81	139	94	76	130	89	74	114	-	-
80	171	112	88	155	103	82	143	96	79	125	-	-
90	189	123	95	170	111	88	175	104	84	136	-	-
100	207	133	103	186	120	94	170	111	89	147	-	-
110	225	143	110	201	129	100	184	118	94	158	104	-
120	242	154	117	216	138	106	197	125	99	169	109	-
130	260	164	125	232	146	113	210	132	104	180	115	-
140	278	175	132	247	155	119	224	139	109	192	121	-
150	296	185	140	263	164	125	237	147	114	203	126	101
160	314	196	147	278	172	131	250	154	118	214	132	104
170	332	206	154	293	181	137	264	161	123	225	137	108
180	350	216	162	309	190	143	277	168	128	236	143	112
190	367	227	169	324	198	149	291	175	133	247	148	115
200	385	237	176	339	207	155	304	182	138	258	154	119
225	430	263	195	378	229	170	337	200	150	286	168	128
250	475	289	213	416	251	185	371	218	162	314	182	138
275	519	315	231	455	272	200	404	236	175	342	196	147
	Interior width			Interior width			Interior width			Interior width		
	150	200	300	150	200	300	150	200	300	150	200	300
	Interior length											
300	341	250	168	290	213	145	254	187	131	223	165	120
325	367	268	180	312	228	155	272	199	138	238	175	126
350	393	287	192	334	243	165	290	211	146	253	184	132
375	420	305	203	356	258	174	308	223	153	267	194	137
400	446	323	215	377	274	184	325	236	161	282	204	143
425	472	342	226	399	289	193	343	248	168	296	213	149
450	498	360	238	421	304	202	361	260	176	311	223	154
475	524	378	249	443	319	212	379	272	183	326	232	160
500	550	397	261	464	334	221	397	284	190	340	242	166
600	654	470	307	551	395	259	469	333	220	399	280	188
700	758	544	354	638	455	297	540	382	250	457	319	211
800	862	617	400	725	516	335	612	431	280	516	357	234
900	966	691	446	812	577	372	683	480	310	574	395	256
1,000	1,071	765	492	899	640	410	755	529	340	633	433	279

Other Construction Constraints

Designing the earth embankment

The top width of the berm around the lagoon should be at least 8 feet. When constructing the berm, allow an extra 10 percent for settling. If possible, the berm should be capped with topsoil and seeded to grass. The outside slope of the lagoon berm should be at least 3 feet of run to 1 foot of rise if animals will be grazing on the land and 5 to 1 if the area is to be mowed by a tractor.

A safety volume or freeboard of 2 feet has been calculated into the dimensions in Table 4 to allow for unusually heavy rainfalls such as a 25-year, 24-hour storm. This precaution will usually prevent the lagoon from overflowing. A gravelled slope with a ratio of no more than 15 to 1 should also be included somewhere in the embankment design so that tractors will have access to the lagoon for dewatering, agitating, or mowing.

Designing the inlet and outlet

Open channel versus pipe. When a lagoon is sited below the source of waste, it is possible to use gravity to feed the lagoon and deliver the waste in either open channels or pipes. Open channels provide easy access for cleaning and have greater liquid-carrying capacity. They do, however, freeze in winter and may add to odor problems. Pipes can be used for a system that collects animal waste in a sump and pumps it to the lagoon. Eight- to 10-inch pipes with cleanouts and rigid joints are ideal to transport the waste.

The inlet to the lagoon can be either above or below the water surface. Any inlet should project at least 20 feet into the lagoon and should be supported every 8 feet. It should discharge into at least 3 to 5 feet of liquid depth. If the inlet is above the surface, it may freeze during winter. When it is below the surface, the system requires pressure to work properly and it may require daily cleaning with fresh water in isolated cases to control blockages.

Outlet to next lagoon. In a multiple-stage system, the outlet or overflow to the next lagoon should be able to handle one-and-a-half times the peak daily inflow of waste. A typical overflow device is a 6-inch pipe (trickle tube) through the first lagoon's berm. The pipe is tilted 1 foot on an uphill slope so that the liquid enters the pipe 1 foot below the surface of the first lagoon. The pipe's submerged inlet keeps floating solids out of the second lagoon stage. Locate the trickle tube or outlet pipe as far away from the inlet pipe as possible. A T-tube may also be used to hold floating solids back.

Designing the pumping system

Placement. In many cases, it is necessary to use a sump pump to either pump the waste to a lagoon that is higher than the source or to pump waste to a site where it can easily be screened. A sump pit is used to collect the waste at a low point common to all the animal confinement areas. A sump pump is placed in this pit to lift the waste to the screen or the lagoon. The sump pit must be large enough for a person to work in, and it should contain a device to close the inlet pipe while work is being done. The sump pit must never be entered until adequate ventilation has removed potentially lethal gases.

*Selecting equipment.*Use a commercial-grade sewer pump with either an automatic or a manual switch. Automatic switches include flotation, mercury, or pressure switches that are automatically activated when the sump pit is full. To minimize salt and crystal buildup problems around the pump and sump pit, a secondary pipe circuit may be included to flush a 30-percent hydrochloric acid solution around the pump to dissolve the salt. Also, use smooth-walled plastic pipes and as few joints and elbows as possible to help reduce salt buildup. Ground pumps correctly to ensure that a voltage differential does not encourage crystalline buildup.

Operation and Maintenance

Starting up

Start up new anaerobic lagoons in spring or summer to ensure maximum bacterial reproduction, waste digestion, and stabilization before cold weather. The first stage of the start-up procedure is filling the lagoon with clean water to at least one-third of its total volume. Sources of clean water may be nearby streams, lakes, wells, or directed surface runoff and roof drainage.

The second stage of the start-up procedure is to gradually increase manure loading. Start by adding waste at one-fourth of the normal recommended loading rate during the first two months. Over the next two months, add half the normal amount; and over the fifth and sixth months, add three-fourths of the normal loading rate. After six months, the lagoon should be ready to receive the full loading rate of manure. Until the lagoon is ready, store the manure or apply it to the land.

Odors may occur during start-up. If they become severe, decrease the loading rates or begin the start-up procedure again.

Breaking a crust

Sometimes solids float on the surface of the lagoon, forming a crust. This crust helps to maintain anaerobic conditions, keep temperature constant, and minimize offensive odors. Odors may be released when the crust is broken during pump-down. The crust should be broken and removed when it becomes more than 1 foot deep. To do this, pump liquid on top of it during agitation with a chopper-type pump.

Inspecting the lagoon

Inspect lagoons regularly to ensure odor control, overflow control, fly control, and proper lagoon operation. Mow grass and weeds around the lagoon's embankment to simplify inspection, decrease the organic loading rate, and discourage flies and mosquitoes. Keep trees from growing on the embankments; their roots may destroy the berm or leave root channels that seep. Use a permanent post gauge in the lagoon to determine volumes and dewatering times.

Removing sludge

Remove sludge when the buildup occupies about one-third of the lagoon's total design volume. Sludge can be removed by using agitation, sludge pumps, a hydraulic dredge, or a dragline. It can then be disposed of with surface or large-bore sprinkler irrigation systems if enough dilution water is used. Semisolid sludge can be hauled with manure spreaders; diluted sludge can be irrigated directly onto land if there is no danger of damaging the leaves of a growing crop.

Testing fertility

Animal waste is high in nitrogen, potassium, and phosphorus. During lagoon operation, nitrogen is converted to ammonia, leaving a small amount of nitrogen in the sludge. Phosphorus accumulates in the sludge so little is lost; and most of the potassium remains in solution in the lagoon. Take representative lagoon samples regularly and analyze them before pumping the lagoon.

Controlling odor

Odor is one of the greatest problems associated with livestock waste lagoons. It usually seems stronger in the spring because the organic matter has not been completely digested during the winter. To prevent odor problems, use the correct start-up procedure, add the right amount of dilution water, and decrease the loading rates during winter and early spring.

Lime and nitrates can be added, but they are an expensive and temporary solution. Several enzyme products, available as deodorants and disinfectants, can be used to treat lagoon odor. These products can be very costly; test them first by using the recommended dosage in a 5-gallon container of lagoon liquid. Then prepare an untreated sample of the same size. After a few days, compare the smell of the two samples to assess the product's effectiveness.

When the problem is severe, plastic coverings over the lagoon can be an expensive but efficient method of odor control. Aeration equipment—for example, mechanical aerators—are effective, but they are initially expensive, have high operating costs, and require maintenance. Odor problems may be intense during the first two weeks after installation, but they should become less intense after a few months of operation.

Dewatering the lagoon

Pump the lagoon down to its minimum design volume when the water level reaches or is near the bottom of the freeboard. The type and size of the dewatering irrigation equipment depends on the size of the lagoon and the solids content of the liquid manure. It will also depend on the solids content of the waste water. Thus, the irrigation equipment can vary from 2-horsepower gasoline pumps with 1-1/4-inch black plastic pipe and lawn-type sprinklers to the "big-gun" sprinklers with large nozzles. The big-gun sprinklers require pressures up to 100 pounds per square inch and pumping rates up to 800 gallons per minute. An alternative for medium-sized systems is gated pipe laid on a contour.

Tank wagons can transport fluids in capacities ranging from 400 to about 3,000 gallons, but they are more expensive and time-consuming than irrigation systems unless the lagoon's volume is less than about 75,000 cubic feet. Tank wagons are commonly loaded with either centrifugal, vacuum, or helical rotor high-capacity pumps; and they can spread the manure evenly on both sides or one side of the wagon.

Guaranteeing safety

Lagoons are potentially dangerous places. Install fences around lagoons to prevent easy access and place warning signs at intervals around the fence. It is important to ventilate sump pits properly to prevent buildup of lethal concentrations of gases such as hydrogen sulfide, ammonia, carbon dioxide, and methane. Enter a manure pit only after it has been well ventilated. Make sure that anyone entering the pit has a breathing apparatus and that two people are on hand to pull out anyone who collapses. Keep open flames away from sump pits because methane is highly explosive.

Worksheet Example

Example: A swine producer has 500 nursery pigs and 525 finishing hogs near Urbana. The producer wishes to construct a two-stage anaerobic lagoon that requires two dewaterings a year.

The value shown, 82, gives volume of the first stage of a two-stage lagoon for each growing pig. Total will be 500 pigs x 82 cu ft/pig = **41,000 cu ft.**

The value shown, 49, gives the volume of the second stage of a two-stage lagoon for each growing pig. Total is 500 pigs x 49 cu ft/pig, which is equal to **24,500 cu ft.**

Table 1. Determining Volume for Lagoons in Central Illinois

	Weight, lb.		One dewatering: Single-stage	One dewatering: Multiple-stage 1st	One dewatering: Multiple-stage 2nd	Two dewaterings: Single-stage	Two dewaterings: Multiple-stage 1st	Two dewaterings: Multiple-stage 2nd
			cubic feet of lagoon volume per animal					
Swine:								
Nursery pig	35	mdv	48	44	13	48	44	12
		total	75	44	40	62	44	27
Growing pig	65	mdv	88	82	23	88	82	23
		total	140	82	75	114	$\boxed{82}$	$\boxed{49}$
Finishing hog	150	mdv	203	188	53	203	188	53
		total	323	188	173	262	$\boxed{188}$	$\boxed{113}$
Gestation sow	275	mdv	372	344	97	371	344	96
		total	592	344	317	482	344	207
Sow + litter	375	mdv	507	469	132	506	469	131
		total	807	469	432	657	469	282
Beef:								
	500	mdv	750	625	251	750	625	252
		total	1,090	625	590	920	625	420
	750	mdv	1,125	938	376	1,125	938	378
		total	1,635	938	895	1,380	938	630
	1,000	mdv	1,500	1,250	500	1,500	1,250	504
		total	2,180	1,250	1,180	1,840	1,250	840
	1,250	mdv	1,875	1,562	626	1,875	1,562	630
		total	2,725	1,562	1,475	2,300	1,562	1,050
Dairy:								
	150	mdv	264	225	75	263	225	75
						338	225	150
						438	375	125
						563	375	250
						878	750	250
						1,125	750	500
	1,000	mdv	1,760	1,				
		total	2,750	1,				
	1,400	mdv	2,464	2,				
		total	3,850	2,				

NOTE: mdv = minimum design volume; total = total volume

The value shown, 188, gives the volume of the first stage of a two-stage lagoon for each finishing pig. Total is 525 pigs x 188 cu ft/pig = **98,700 cu ft.**

The value shown, 113, gives the volume of the second stage of a two-stage lagoon for each finishing pig. Total is 525 pigs x 113 cu ft/pig = **59,325 cu ft.**

The **total volume** for the first-stage lagoon for treating waste produced from 500 growing pigs and 525 finishing hogs would be 41,000 cubic feet + 98,700 cubic feet = **139,700 cubic feet.**

The **total volume** for the second stage would be 24,500 cubic feet + 59,325 cubic feet = **83,825 cubic feet.**

Worksheet Example

The producer requires lagoons that are approximately 12 feet and 15 feet deep respectively, due to the presence of limestone in the area. Both lagoons should also be roughly square to make maximum use of available space.

The volume of the first lagoon is approximately 140,000 cu ft. At a depth of 12 ft, the most square dimensions would be 150 ft by 155 ft. 155 ft appears horizontally across from the required volume.

Table 4. Interior Dimensions for Livestock Waste Lagoons

Bank slope = 2.5:1; dimensions include 2-foot freeboard; all dimensions in feet, unless otherwise specified.

	Depth											
	10			12			15			20		
Volume	Interior width			Interior width			Interior width			Interior width		
1,000s cu ft	100	150	200	100	150	200	100	150	200	100	150	200
	Interior length											
10	46	-	-	-	-	-	-	-	-	-	-	-
20	64	50	-	63	-	-	63	-	-	-	-	-
30	82	60	-	78	-	-	77	-	-	-	-	-
40	100	71	-	93	68	-	90	68	-	-	-	-
50	117	81	66	109	77	-	103	75	-	-	-	-
60	135	91	73	124	85	70	117	82	70	103	-	-
70	153	102	81	139	94	76	130	89	74	114	-	-
80	171	112	88	155	103	82	$\boxed{143}$	96	79	125	-	-
90	189	123	95	170	111	88	175	104	84	136	-	-
100	207	133	103	186	120	94	170	111	89	147	-	-
110	225	143	110	201	129	100	184	118	94	158	104	-
120	242	154	117	216	138	106	197	125	99	169	109	-
130	260	164	125	232	146	113	210	132	104	180	115	-
140	278	175	132	247	$\boxed{155}$	119	224	139	109	192	121	-
150	296	185	140	263	164	125	237	147	114	203	126	101
160	314	196	147	278	172	131	250	154	118	214	132	104
170	332	206	154	293	181	137	264	161	123	225	137	108
180	350	216	162	309	190	143	277	168	128	236	143	112
190	367	227	169	324	198	149	291	175	133	247	148	115
200	385	237	176	339	207	155	304	182	138	258	154	119
225	430	263	195	378	229	170	337	200	150	286	168	128
250	475	289	213	416	251	185	371	218	162	314	182	138
275	519	315	231	455	272	200	404	236	175	342	196	147
300												
325												
350	393	287	192	334	243	165	290	211	146	253	184	132
375	420	305	203	356	258	174	308	223	153	267	194	137
400	446	323	215	377	274	184	325	236	161	282	204	143
425	472	342	226	399	289	193	343	248	168	296	213	149
450	498	360	238	421	304	202	361	260	176	311	223	154
475	524	378	249	443	319	212	379	272	183	326	232	160
500	550	397	261	464	334	221	397	284	190	340	242	166
600	654	470	307	551	395	259	469	333	220	399	280	188
700	758	544	354	638	455	297	540	382	250	457	319	211
800	862	617	400	725	516	335	612	431	280	516	357	234
900	966	691	446	812	577	372	683	480	310	574	395	256
1,000	1,071	765	492	899	640	410	755	529	340	633	433	279

For the second-stage lagoon, a volume of 83,825 ft is required at a depth of 15 ft. The figure across from this volume under the 15 ft depth, 143 ft, combined with an interior width of 100 ft, would give the nearest square dimensions.

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